Final Report

A project under the Canada-New Brunswick Conservation and Renewable Energy Demonstration Program

ENERGY EFFICIENT HOUSE

VB 21

Grove Hamlet
Moncton, N.B.

W.H. Crandall & Assoc. Ltd.
March, 1984

C.R.E.D.A Project # 2030

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Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

Conservation & Renewable
Energy Division
Energy Secretariat
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Fredericton, N.B.
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Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Energie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

Division des économies d'énergie
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D I S C L A I M E R

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D E N I D E R E S P O N S A B I L I T E

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ENERGY EFFICIENT HOME

GROVE HAMLET S/D

MONCTON, N.B.

FINAL REPORT

FEBRUARY 1985

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1.0 EXECUTIVE SUMMARY

As outlined in our proposal, the objective of this energy efficient housing demonstration was to test the practical benefits of energy saving options available in today's market place.

It was the intent of this exercise to document several major construction problems associated with energy efficient implementation. They would consist of:

a) overheating and ventilation;

b) shutters and overhangs;

c) housing orientation;

d) air tightness, and;

e) developing construction applications to limit labour/ contractor site techniques.

Prior to construction many of these options were thoroughly investigated. Those that appeared to have the most theoretical cost - benefit advantages for this area were selected for the project.

During these investigations mock-ups of wall and ceilings with varying thicknesses of insulation were constructed to verify their ease of construction and to indicate any unforseen problems. Graphs of the sun's horizontal and vertical angles were also plotted so that eave overhangs and house orientation could be studied.

Factors applied during the investigation of these options were:

a) Cost payback time, where extra cost was calculated and applied to the finance package, then compared to the theoretical energy savings.

b) Ease of construction where options were selected that fit in well with normal construction methods in this area thereby avoiding extra labour costs.

The final energy saving options were then selected and incorporated into the construction drawings. A monitoring system was devised that was economical, easily observed, and would provide the information required to analyze the performance of the project.

The original intention was to construct and monitor up to five homes, but the severe economic recession forced us to halt the project after the completion of one house.

The success of this demonstration was excellent in that energy savings were proved economically feasible. Problems encountered with attempts at saving energy were demonstrated and solutions and recommendations are outlined in this report.

1.0 SOMMAIRE-RECOMMANDATION

Comme l'indiquait notre projet, l'objectif de cette démonstration d'habitation à haute efficacité énergétique était de vérifier à quel point les options permettant d'économiser l'énergie qu'on peut trouver actuellement sur le marché sont vraiment pratiques.

Cette expérience avait également pour objet de recueillir de l'information sur plusieurs problèmes sérieux de construction associés à l'adoption des techniques d'économie de l'énergie. Il s'agit principalement:

a) du surchauffage et de la ventilation,
b) des volets et des surplombs,
c) de l'orientation de l'habitation,
d) de l'étanchéité à l'air et
e) de la mise au point de méthodes de construction permettant de réduire les exigences techniques sur place pour l'entrepreneur et son équipe de construction.

Avant de procéder à la construction, un grand nombre de ces options ont fait l'objet d'une étude approfondie. Celles qui furent choisies pour le projet sont celles qui théoriquement semblaient offrir le meilleur rendement dans cette région.

Pour effectuer cette étude, des maquettes avec des murs et des plafonds de diverses épaisseurs d'isolation furent assemblées afin de vérifier leur facilité de construction et de faire ressortir tout problème imprévu. On traça également des graphiques donnant les angles horizontaux et verticaux du soleil afin de pouvoir déterminer la longueur du surplomb de l'avant-toit ainsi que l'orientation de la maison.

Les facteurs utilisés pour l'étude de ces options étaient:

a) Le recouvrement prévu, en calculant les coûts supplémentaires et en les incluant dans les obligations financières, puis en comparant ce supplément aux économies d'énergie théoriques.

b) La facilité de construction, dans le cas des options choisies qui s'adaptaient bien aux méthodes de construction habituelles dans la région et qui permettaient par conséquent d'éviter des frais supplémentaires au niveau de la main-d'oeuvre.

C'est alors seulement que furent choisies les options permettant des économies d'énergie et que ces dernières furent incorporées aux plans de construction. Un système de monitorage économique et facile à observer fut alors mis au point pour recueillir les données nécessaires pour analyser le rendement du projet.

Le projet original consistait à construire jusqu'à cinq maisons et à en contrôler le rendement, mais la récession économique a été telle qu'elle nous a obligés à interrompre le projet après la construction de la première maison.

Cette démonstration a été un véritable succès, car les économies d'énergie se sont révélées économiquement faisables. Les problèmes qui accompagnent les efforts visant à économiser l'énergie ont été démontrés et le rapport présente un certain nombre de solutions et de recommandations en ce sens.

2.0 INTRODUCTION AND BACKGROUND

- This project was initiated to prove the economics of simplified cost effective energy saving options that could be easily incorporated into the housing standards of the province of New Brunswick.

- The objective of this demonstration was to incorporate these options into an actual working model to prove their cost effectiveness.

- In selecting energy saving devices to be included in this demonstration a multitude of ideas and or combinations of these devices were investigated. Some of these were Heat Pumps in combination with wood and solar heat, Passive Solar, Active Solar heat and varying degrees of insulation. Others were window blinds, shutters and heat exchangers. Observations of other operating energy efficient homes were also carried out.

- All of these investigations showed the best theoretical options were heavy insulation, air tightness, optional wood heat and a passive solar addition. In addition, an air to air heat exchanger was required to combat indoor air pollution and humidity.

- These options were chosen for their economics, low maintenance, availability, simple operation, and adherence to regular construction practices to avoid high labour costs.

- Savings on heating costs were estimated at 35 - 40% when compared with todays normal construction of R-30 ceilings and R-20 walls.

At present the public is poorly educated on the value of homes that have more than the normal type of energy saving options incorporated in their construction. As we are all aware it took 20 years to get from R-12 walls to R-20 walls. Most home buyers are still more interested in landscaping and aesthetics than the invisible advantages of heavy insulation. Only after paying ever increasing heating bills do home owners realize they should have selected the energy saving options available to the home buyer. It is now up to the sponsors of this project to thoroughly analyze this project, correlate this with other projects and see that minimum building standards are upgraded so that home heating remains affordable. This in turn will help keep the housing market viable.

3.0 DESCRIPTION OF DEMONSTRATION

The energy options selected for the demonstration were:

- Extra heavy insulation and an airtight envelope.
- An air to air heat exchanger.
- Heat recovery from the clothes dryer.
- Optional wood stove provision.
- South orientation for solar heat gain.
- Thermostatic controls to distribute solar and wood heat.

The insulation included R-37 walls, R-52 ceiling and a completely sealed vapour barrier to minimize heat losses through infiltration.

These efforts are shown on the insulation schematic of the house on page 20 of this report.

To minimize humidity and indoor air pollution an air to air heat exchanger was installed with the capability of 0.5 air changes per hour. The clothes dryer was connected to the heat exchanger for heat recovery purposes. Technical data and installation are shown on pages 21 - 23.

A wood stove was installed but use was very limited and no effective results were obtainable. The house was oriented to the south to obtain the maximum solar heat gain. Thermostatic controls were installed to activate the furnace blower and distribute the solar gained and wood stove heat. This also helped to control concentrated humidity problems.

The heating system was central electric forced air with a two stage heating element. All energy use was monitored by kwh meters connected to each energy component as shown on the monitoring schematic, page 24.

As part of this demonstration a well advertised open house program was carried out for approximately four weeks. The project was advertised on the local radio station and interviews of our personnel were broadcast. Advertisements were also placed in the local newspapers.

At the house itself the mock up of the wall construction used was on display. Our personnel were on hand to brief all visitors on the energy efficiency of the house.

As a result of this ad campaign numerous phone calls were received and approximately five hundred visitors were received at the house.

4.0 OBSERVATIONS DURING CONSTRUCTION & MONITORING

During construction most of the components of the energy saving options were errected smoothly with little added labour costs. However, when applying the polystyrene to the exterior walls sealer was used on all joints. This slowed construction somewhat and later proved to be a humidity trap between itself and the interior vapour barrier. The installation of the heat exchanger was relatively straight forward and proved very successful in controlling humidity levels. It was found that fresh air intakes should be insulated and protected with vapour barrier to prevent condensation. Solar gain through the south facing windows was very advantageus and the addition of a thermostat control to the furnace blower distributed this heat nicely. This also helped to control concentrated humidity levels.

During the monitoring portion of this project the success of these energy saving options became readily apparent. The average savings on heating was 48.4%. These savings were a little higher than estimated due to a somewhat warmer winter. The performance cnart on page 8 of this report shows the overall performance of the house compared to a projected cost for a home with R-20 walls and R-30 ceilings.

The data shown on the following chart shows the greatly reduced heating costs:

Month	R-20 Home Projected kwh	R-20 Home Projected Cost	Energy Home Projected kwh	Energy Home Projected Cost	Energy Home Actual kwh	Energy Home Actual Cost	Savings %
Dec.	1,500	58.31	900	34.98	1,085	42.18	28%
Jan.	1,900	73.86	1,200	46.65	1,061	37.14	50%
Feb.	1,700	66.09	1,060	41.21	954	33.39	50%
March	1,500	52.50	900	31.50	740	25.90	51%
April	1,200	42.00	740	25.90	440	15.40	63%

This home was purchased and occupied by a family of four. The purchaser was very happy with the low heating costs, general air quality, and controlled humidity levels.

5.0 COST/BENEFIT ANALYSIS

Government funding through EMR Canada and the Energy Secretariat under the Conservation and Renewable Energy Development and Demonstration Program provided the incentive to proceed with this project. Without this assistance energy saving ideas would remain in the theoretical stage and most would never be demonstrated in the varying regions of Canada. Since Moncton has a history of having lower cost housing compared to other regions, it is even more difficult to market the extra cost of energy saving options.

Most new houses now being built in the area have R-20 walls and R-30 ceilings and heating costs for these houses are fairly acceptable. Thus for comparison purposes we have used the R-20 home.

On this project the energy options, added approximately 10% or $7,000.00 to the cost of the house. It is estimated that on a successive home this could be reduced to $5,000.00 through savings in labour and material costs.

Refering to the cost benefit chart on Page 13 we can see that by using a 10% increase in energy costs per year it will take 6½ years for energy savings to break even with the capital costs.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The sudden depression in the housing market has precluded the construction of further units, preventing further experimentation in construction methods. Our conclusions from the work done on this project are as follows:

- Heavy insulation is a viable way of reducing home heating costs up to a certain point where construction costs will exceed possible savings.
- An airtight envelope in combination with a heat exchanger to ventilate the home is another important energy saver.
- More use of passive solar gain from a southerly exposure in combination with a central forced air heating system can eliminate heating cost on sunny days. A wood stove in combination with this same forced air system would greatly reduce night time heating costs. The wood stove is a cheaper source of heat than either oil or electricity but would require more effort on the homeowner's part.

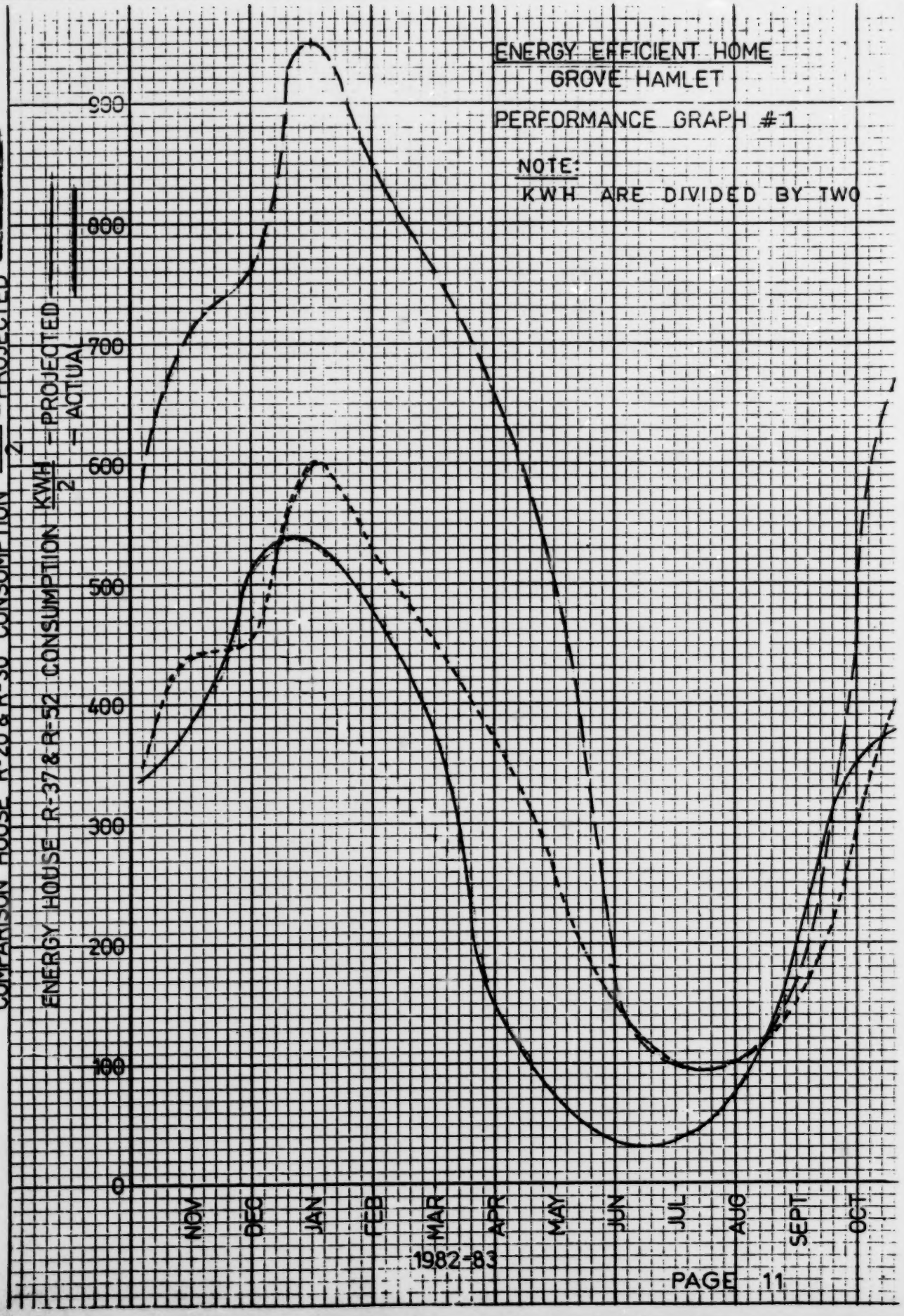
Our recommendations on the use of the above methods are:

- Revise wall construction to a single 2 x 6 stud wall using a non sealed exterior insulating sheathing to provide approximately the same R-value. This will prevent condensation problems in the walls.

- Maintain the airtight envelope with the heat exchanger.
- Reinvestigate the use of a southerly exposure with more glass area. Maintain the central forced air heating system for distribution of solar heat, wood heat and concentrated humidity levels. Provide outside air source for the wood stove.

These recommendations should further reduce heating and construction costs, providing a more marketable energy efficient home.

These options for energy conservation and heating cost reduction can be incorporated into the medium priced housing market and may well be applicable to some extent to lower priced housing industry.


ENERGY EFFICIENT HOME
GROVE HAMLET
PERFORMANCE GRAPH #1
NOTE:
KWH ARE DIVIDED BY TWO
COMPARISON HOUSE R-20 & R-30 CONSUMPTION KWH/2 - PROJECTED
ENERGY HOUSE R-37 & R-52 CONSUMPTION KWH/2 - PROJECTED
= ACTUAL
900
800
700
600
500
400
300
200
100
0
NOV
DEC
JAN
FEB
MAR
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AUG
SEPT
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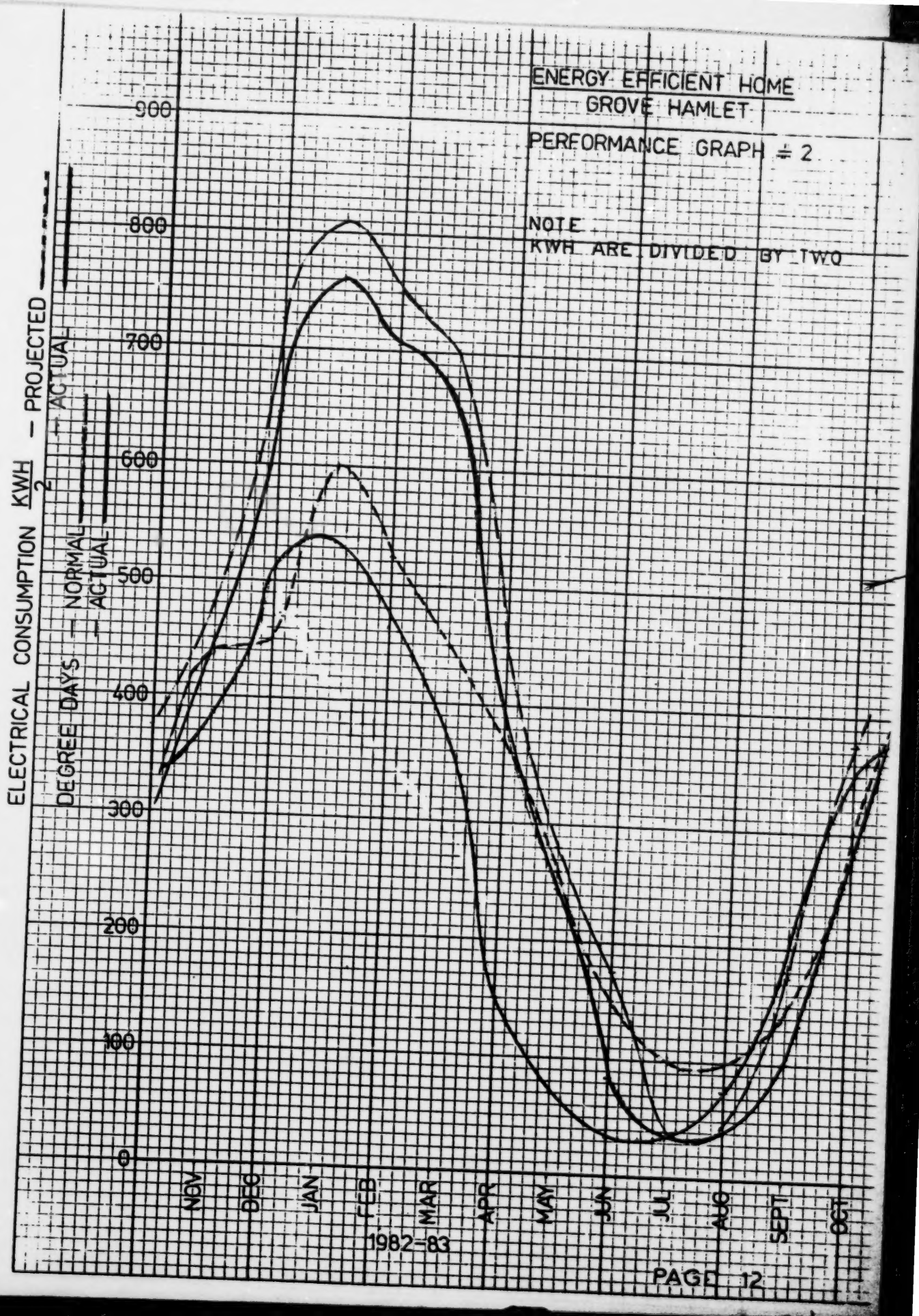
1982-83


ENERGY EFFICIENT HOME
GROVE HAMLET
PERFORMANCE GRAPH ÷ 2
NOTE
KWH ARE DIVIDED BY TWO
ELECTRICAL CONSUMPTION KWH/2 — PROJECTED
— ACTUAL
DEGREE DAYS — NORMAL
— ACTUAL
900
800
700
600
500
400
300
200
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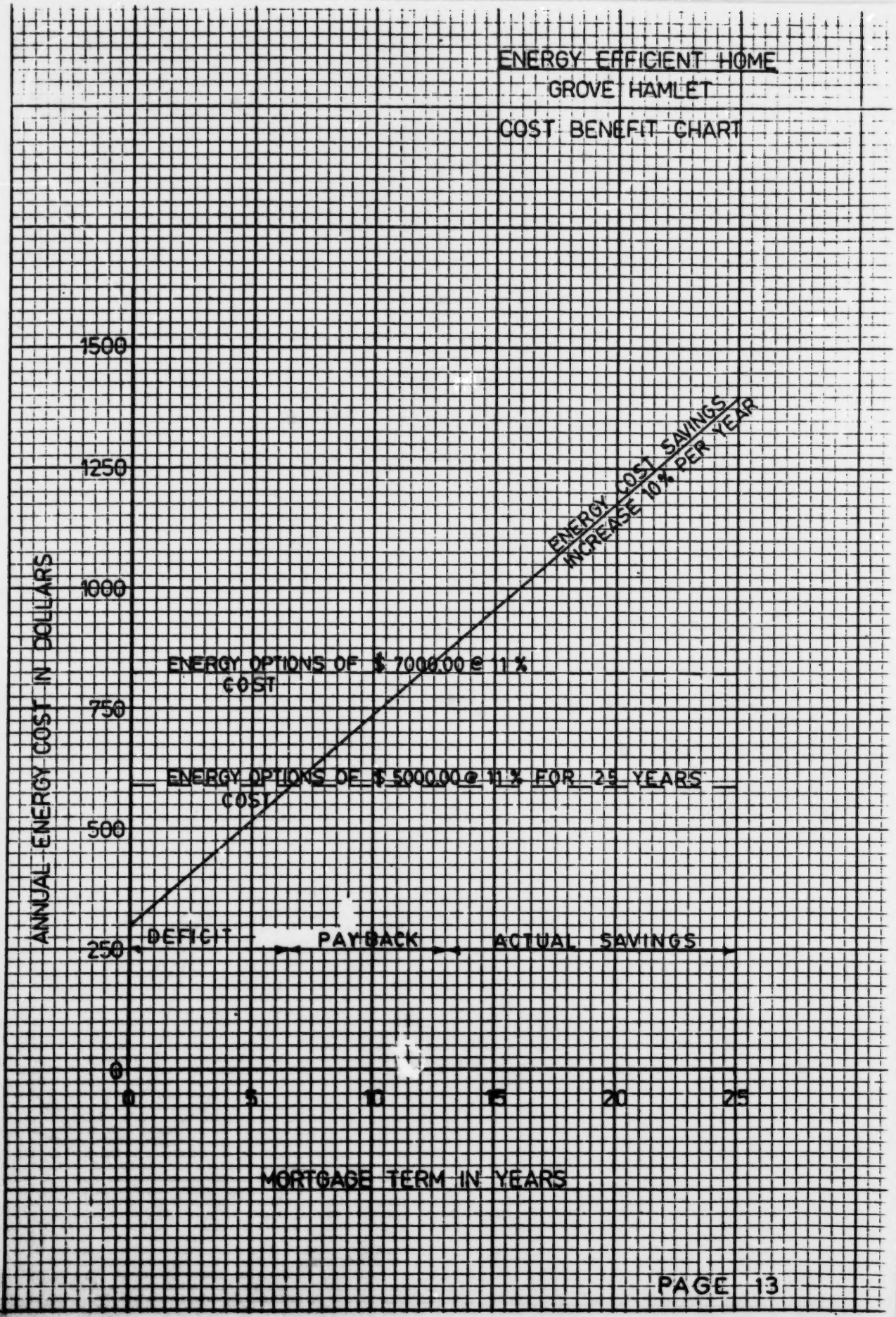
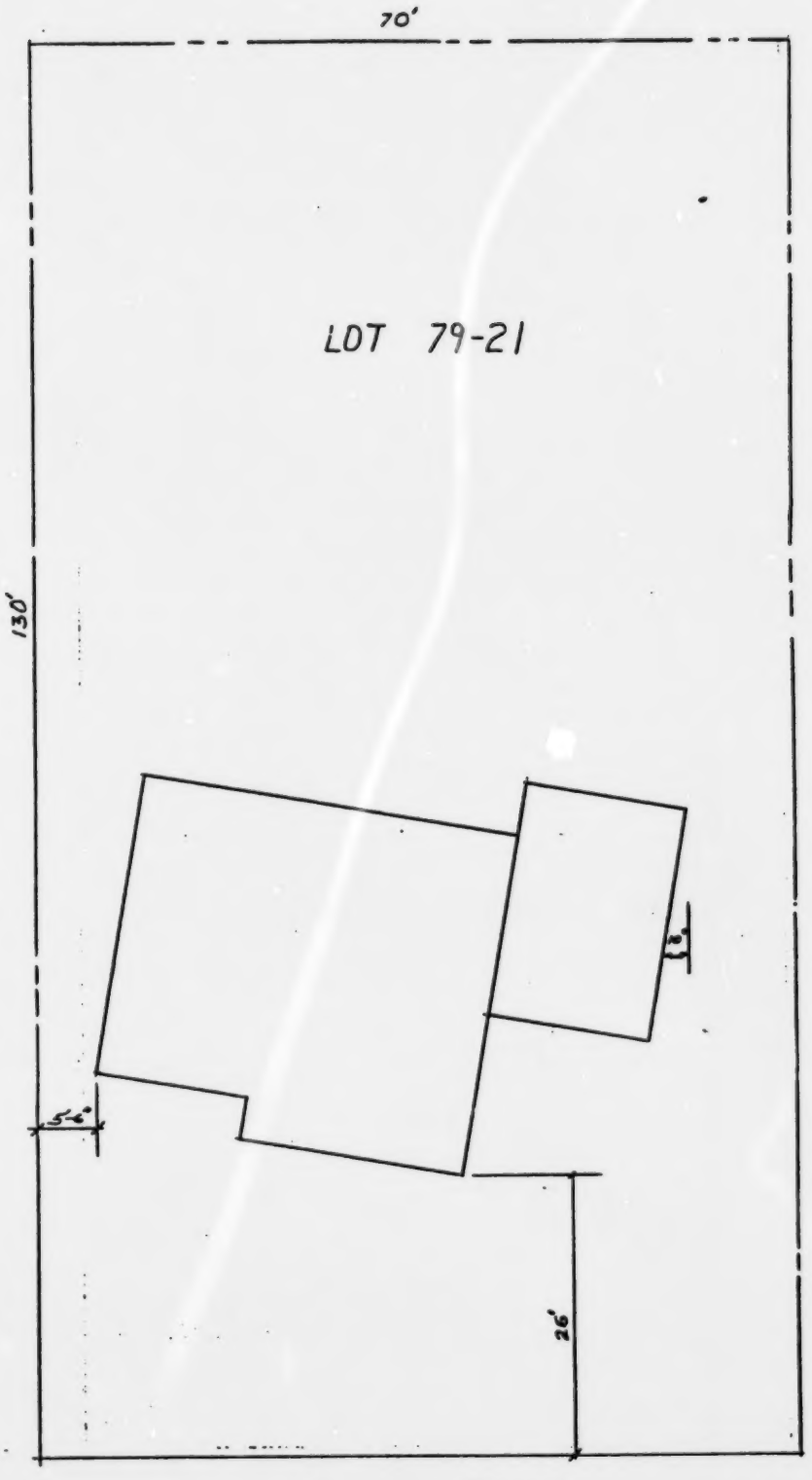
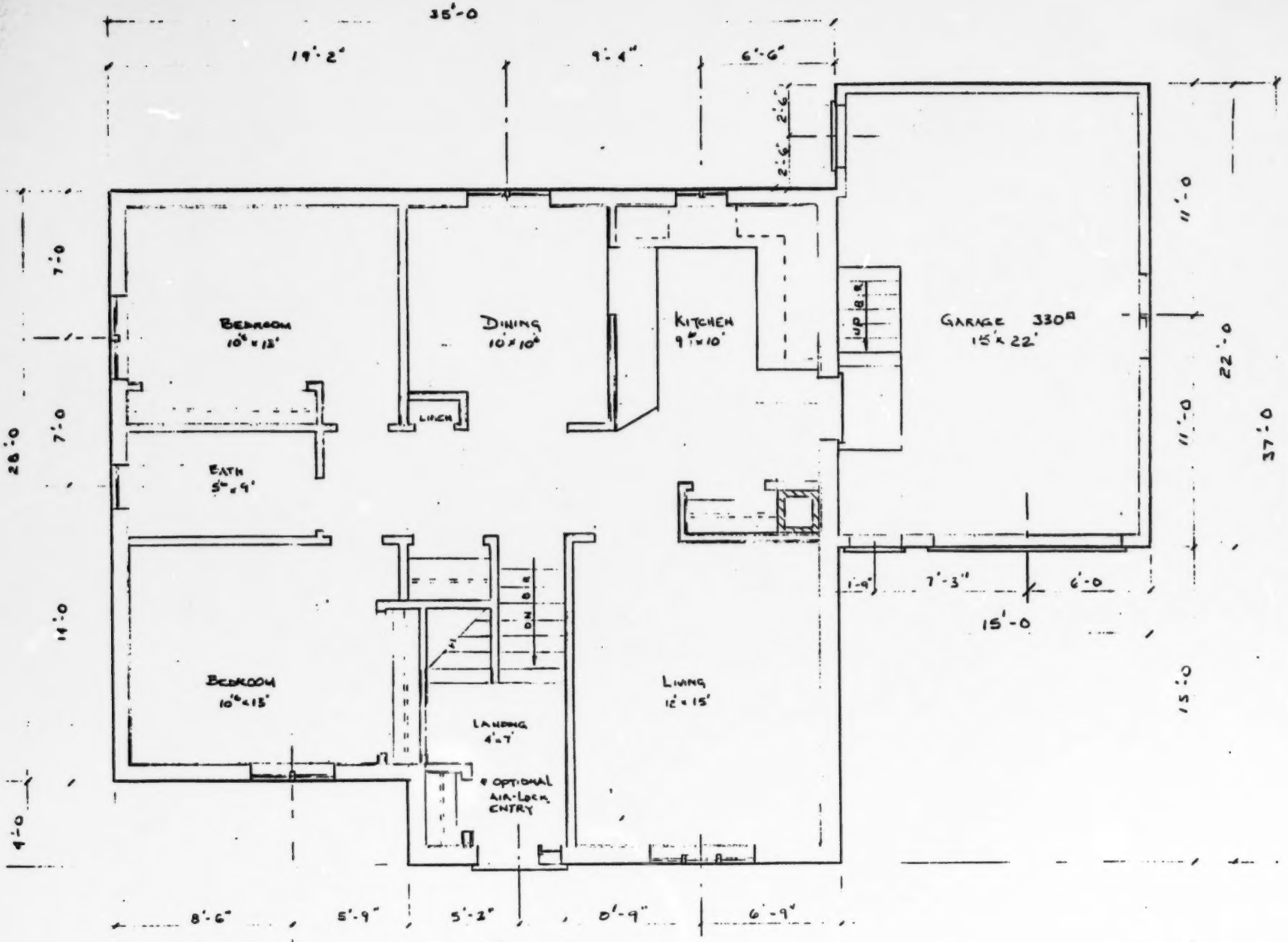
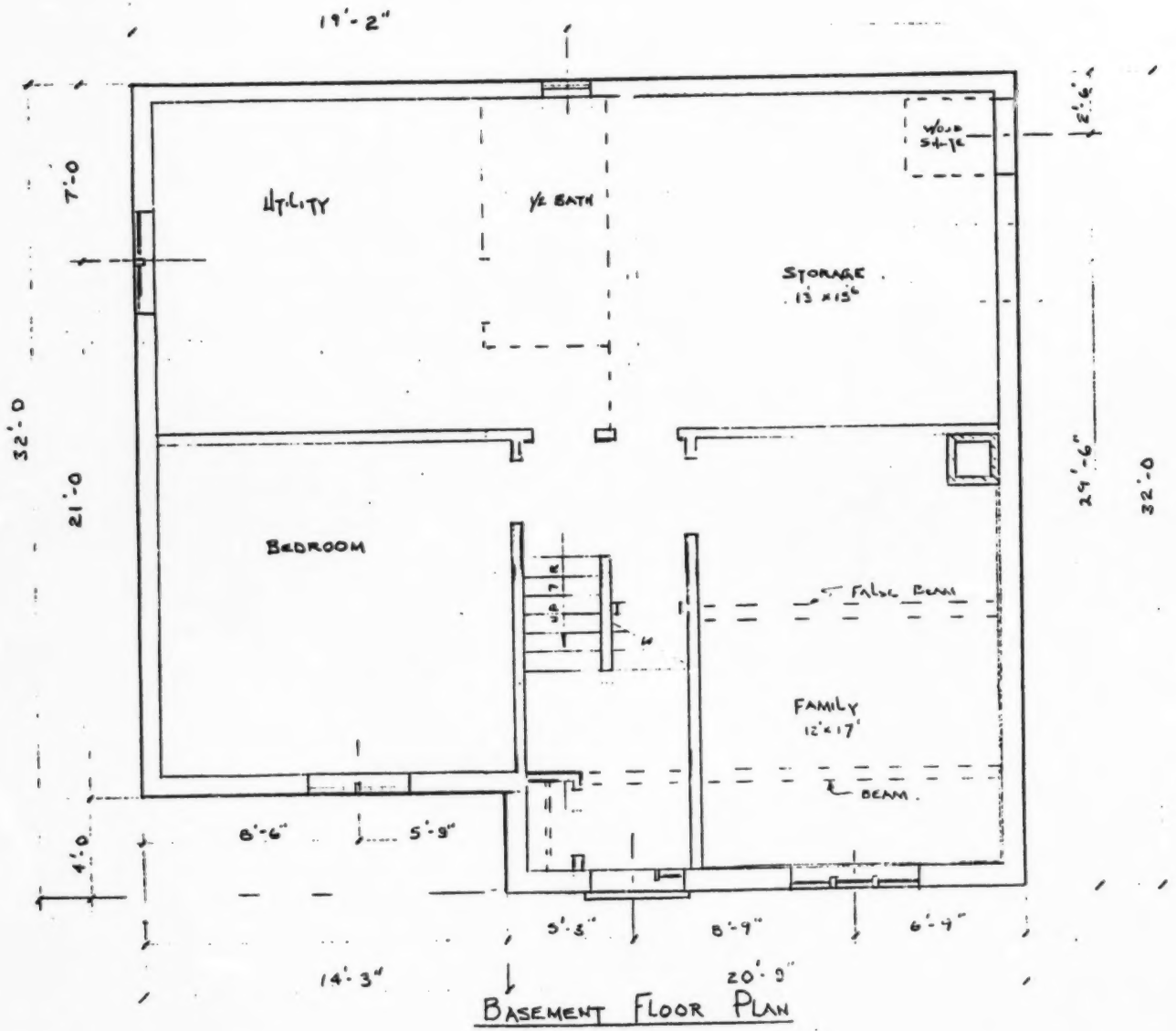

ENERGY EFFICIENT HOME
GROVE HAMLET
COST BENEFIT CHART
1500
1250
1000
750
500
250
0
ANNUAL ENERGY COST IN DOLLARS
ENERGY COST SAVINGS INCREASE 10% PER YEAR
ENERGY OPTIONS OF $7000.00 @ 11 % COST
ENERGY OPTIONS OF $5000.00 @ 11 % FOR 25 YEARS COST
DEFICIT
PAYBACK
ACTUAL SAVINGS
0
5
10
15
20
25
MORTGAGE TERM IN YEARS



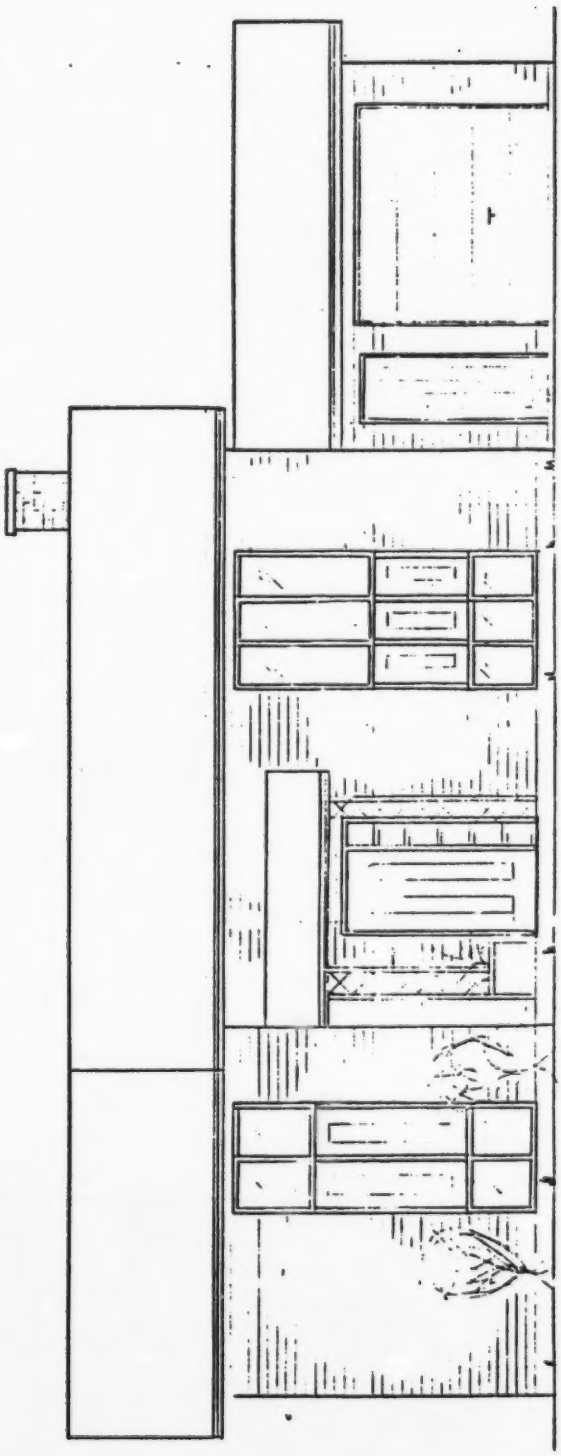
SITE PLAN
SCALE: 1" = 10'-0



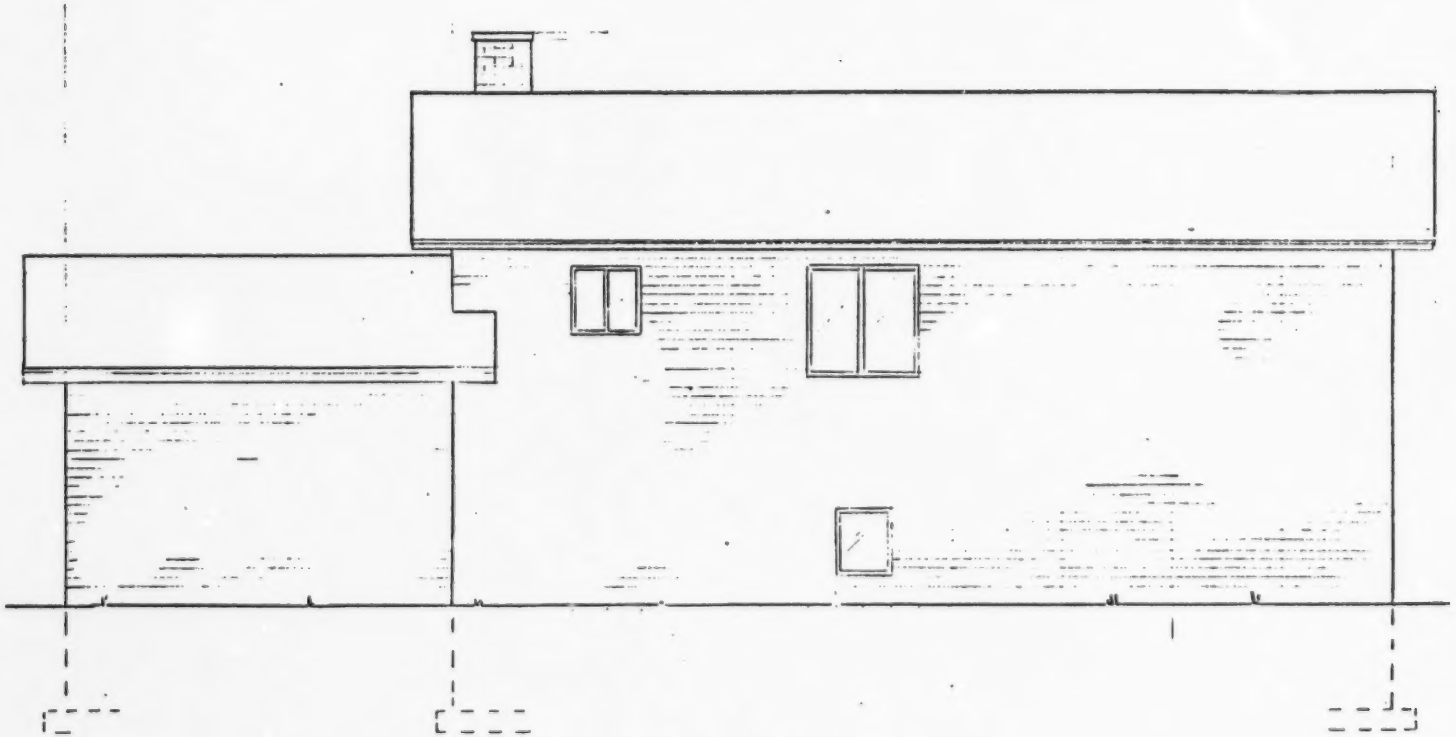
FIRST FLOOR PLAN



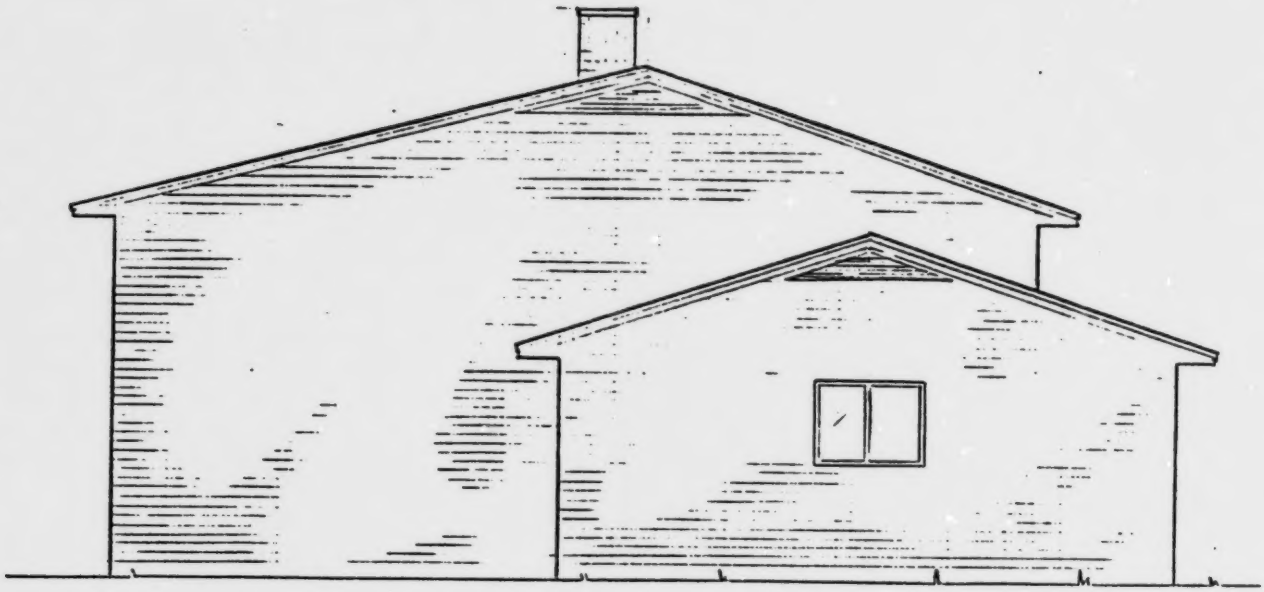
BASEMENT FLOOR PLAN



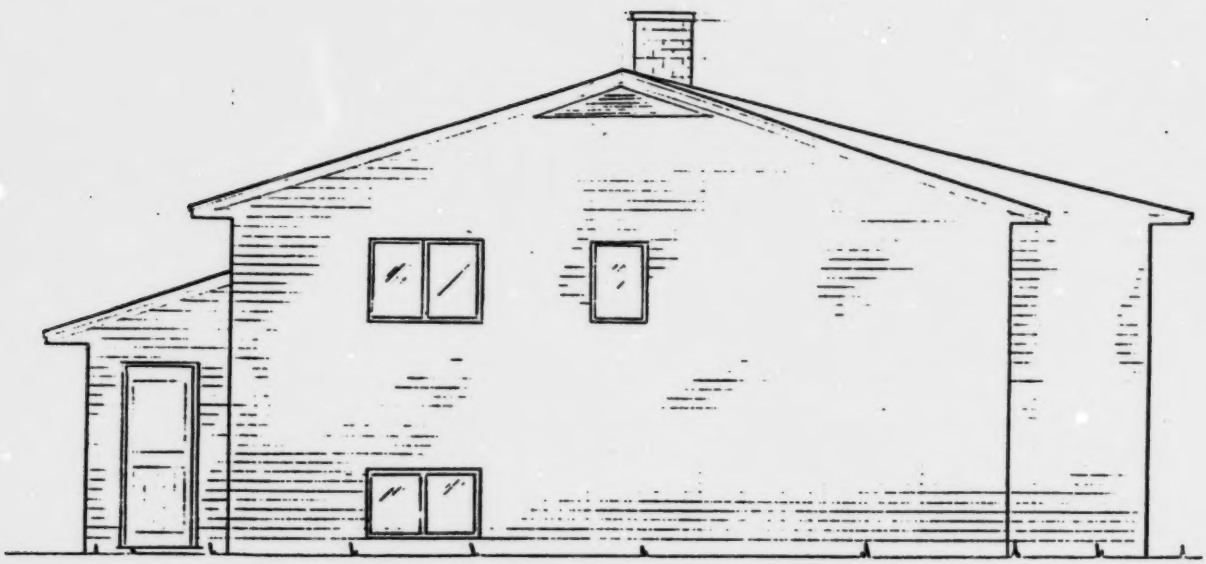
South Elevation



North Elevation



EAST ELEVATION



WEST ELEVATION

A Joint Project

W.H. Crandall & Associates (Mgt.) Ltd.

New Brunswick Energy Secretariat

Energy, Mines & Resources

Canada

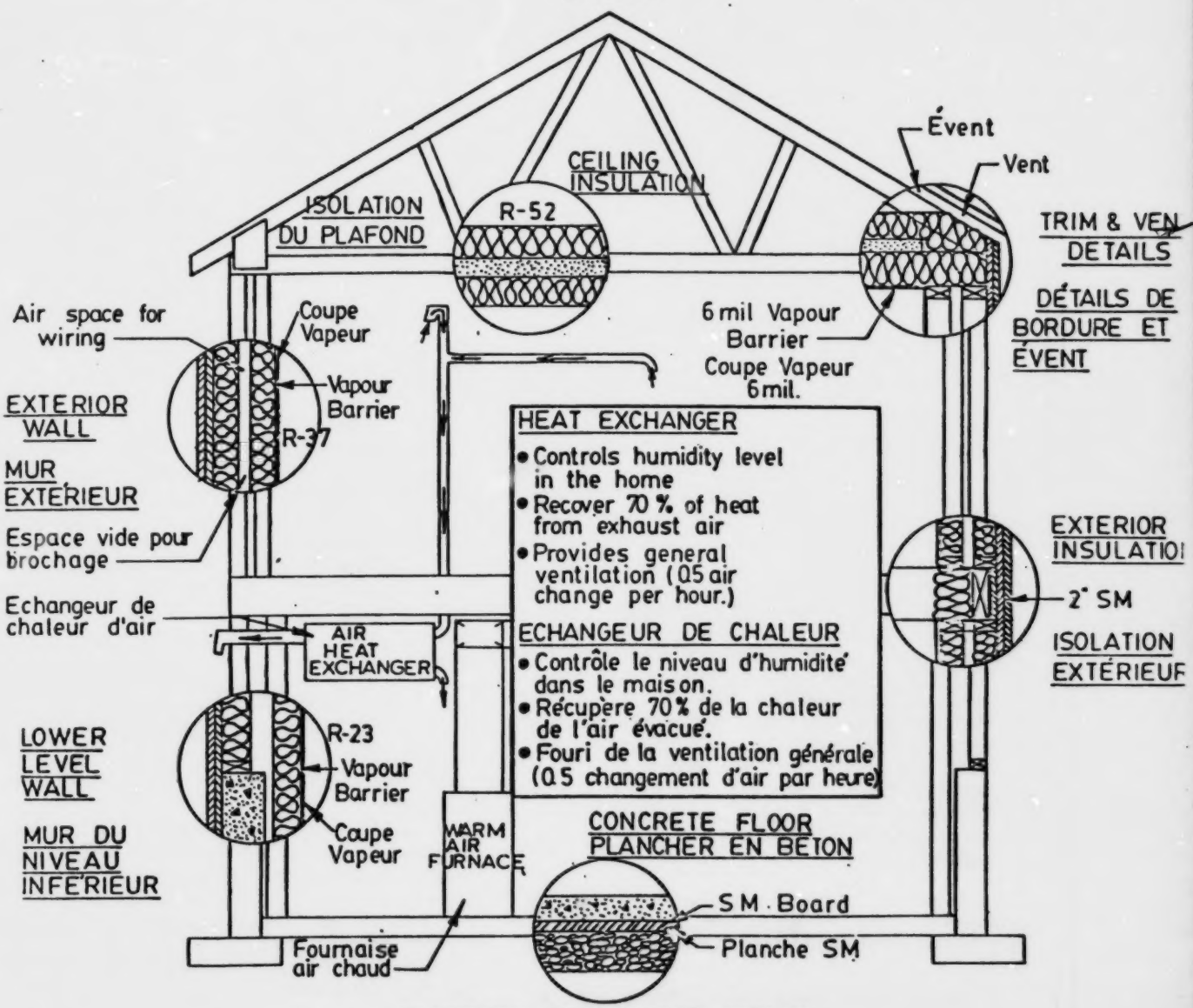
Un Projet Conjoint

W.H. Crandall & Associe's (Mgt.) Lte'e

Secrétariat d'Énergie, Nouveau Brunswick

Énergie, Mines et Ressources

Canada

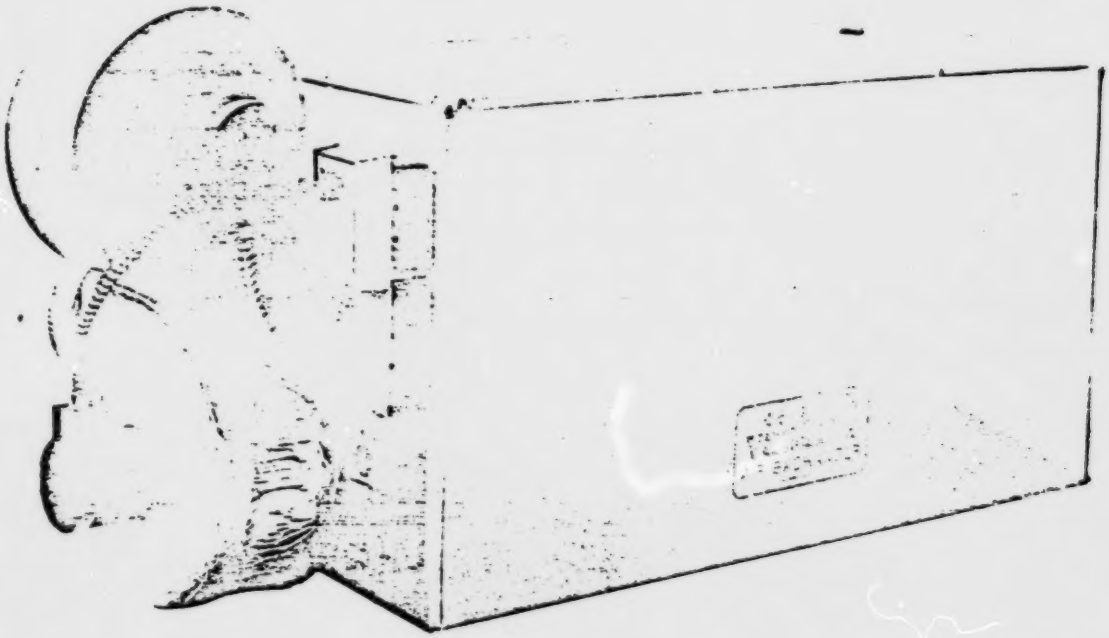


ENERGY EFFICIENT HOME

Grove Hamlet

MAISON EFFICACE EN ÉNERGIE

vanEE AIR EXCHANGERS



MODEL R200

Recent studies show a disconcerting side effect of airtight, energy-efficient homes — indoor air pollution. These contaminants originate not from factories, cars and waste dumps but from construction materials and occupancy of your home.

- Formaldehyde, a bonding agent in foam insulation, also present in plywood and particle board.
- Nitrogen dioxide and carbon monoxide accumulate when gas stoves and heaters are used.
- Particles of soot and benzopyrene foul the air around cigarette smokers.
- Radioactive radon, a natural part of stone, soil and water, seeps into basements through cracked floors and water pipes. It also diffuses out of brick and concrete.
- High levels of humidity can also occur that cause condensation on windows and may damage building materials.

A daily airing of the house may help lower these concentrations — but bringing in cold fresh air certainly defeats the conservation features of an energy-efficient home.

The Canadian designed and manufactured vanEE Air Exchangers use a double-cross flow system which provides effective heat recovery for ventilation of new or retrofitted homes.

Warm, humid, stale air from bathrooms, kitchens, laundry rooms and other living spaces is drawn through a plastic core which has fresh cool air entering from outside. The heat of the exhaust air is absorbed through a common wall into the cool fresh air. The result, preheated fresh air — reduced indoor pollution and continued energy savings.

With a free-air delivery of 118 litres/sec. (250 CFM) the R200 is designed to deliver 94 litres/sec. (200 CFM) with duct work installed. This is sufficient to produce .5 ACH (air changes per hour) in homes with 680m^3 (24,000 FT^3) of occupied space (i.e. a 3000 FT^2 home with standard ceiling height). In homes with less than 340m^3 (12,000 FT^3) of occupied space (i.e. a 1500 FT^2 home) the model R100 will provide .5 ACH.

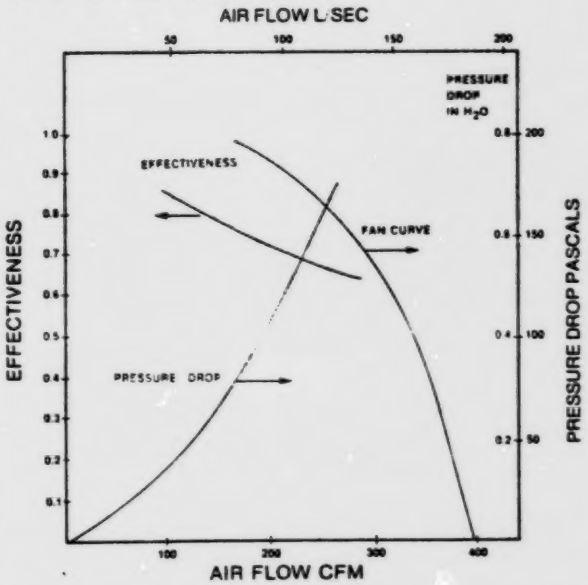
The variable speed motor control allows the exchangers to be run at less than full flow for constant ventilation requirements. This lower speed is by-passed by the dehumidistat or any of the auxiliary switches (i.e. bathrooms, kitchen, laundry) to provide maximum ventilation during these times.

An auto-defrost control prevents blockage by freezing during cold weather.

vanEE

SPECIFICATIONS - MODEL R200

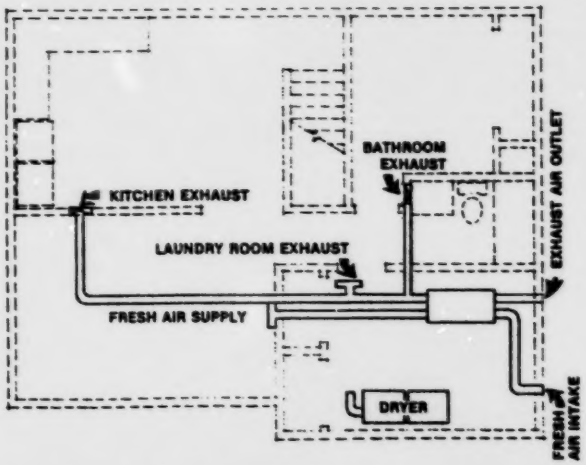
PERFORMANCE DATA



With an efficiency of 71% at 94 Litres/sec. (200 CFM) and 83% at 47 Litres/sec. (100 CFM) the mode R200 provides substantial savings.

EXAMPLE:

- **a house of 111m² (1200FT²) main and basement**
- **.5 ACH (air changes per hour)**
- **a 7 month heating season**
- **11,000 degree days**
- **.025¢ per KWH (kilowatt hour)**
- **15% increase in electrical cost per year**
- **5 year total savings $1,840.63.**



The vanEE Air Exchangers are horizontally mounted from the floor joists and connected to standard 150mm (6") metal duct. A 13mm (½") drain line is provided for condensation.

Free Air Flow — 118 Litres/sec. (250 CFM)
Design Air Flow — 94 Litres/sec. (200 CFM)
Efficiency at 94 Litres/sec. — .71
Efficiency at 47 Litres/sec. — .83
Pressure drop at 94 Litres/sec. — 97.5 pascals (.39 in/H_2O)
Pressure drop at 47 Litres/sec. — 37.5 pascals (.15 in/H_2O)
Dimensions: 380mm (15") wide x 560mm (22") deep x 1200mm (48") long
Ductwork allowance — 81.25 pascals (.325 in/H_2O). Equivalent to 100 lineal feet straight 150mm (6") diameter duct.
All connecting ductwork — 150mm (6") diameter.
Standard mounting location — basement or main floor mechanical room, hung from the ceiling in a horizontal position with supplied hardware.
Operating Controls —

- — Continuous ventilation rate set by variable speed control.
- — Humidity control by dehumidistat
- — Bathrooms, kitchen and laundry ventilation by remote switches (not supplied).
- — Auto-defrost by thermostatic shutoff of outside air.
- — Electrical consumption 115 volts ac, 60 Hz, 2.4 amps.

3 Metres (10') of 13mm (½") vinyl drain hose supplied.
Case constructed of 24 gauge painted galvanized steel with an inner lining of foam insulation to prevent condensation.

One year limited warranty on all parts and labour due to manufacturing defects.

Five year concurrent limited warranty on the exchanger core.

The manufacturer reserves the right to change specifications without notice.

Canadian and United States patents are pending.

Manufactured by D.C. Heat Exchangers Ltd., Saskatoon, Sask. Canada.

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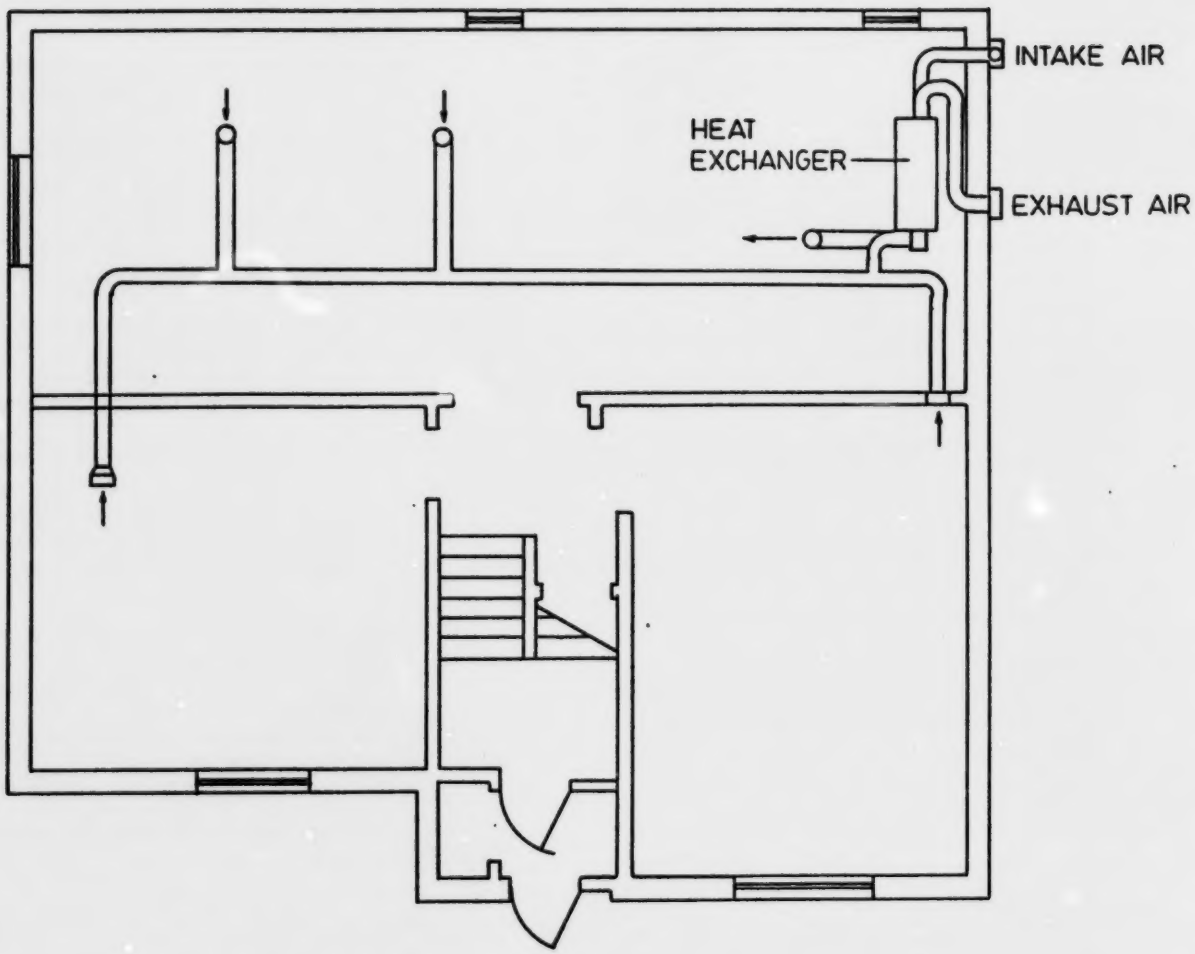
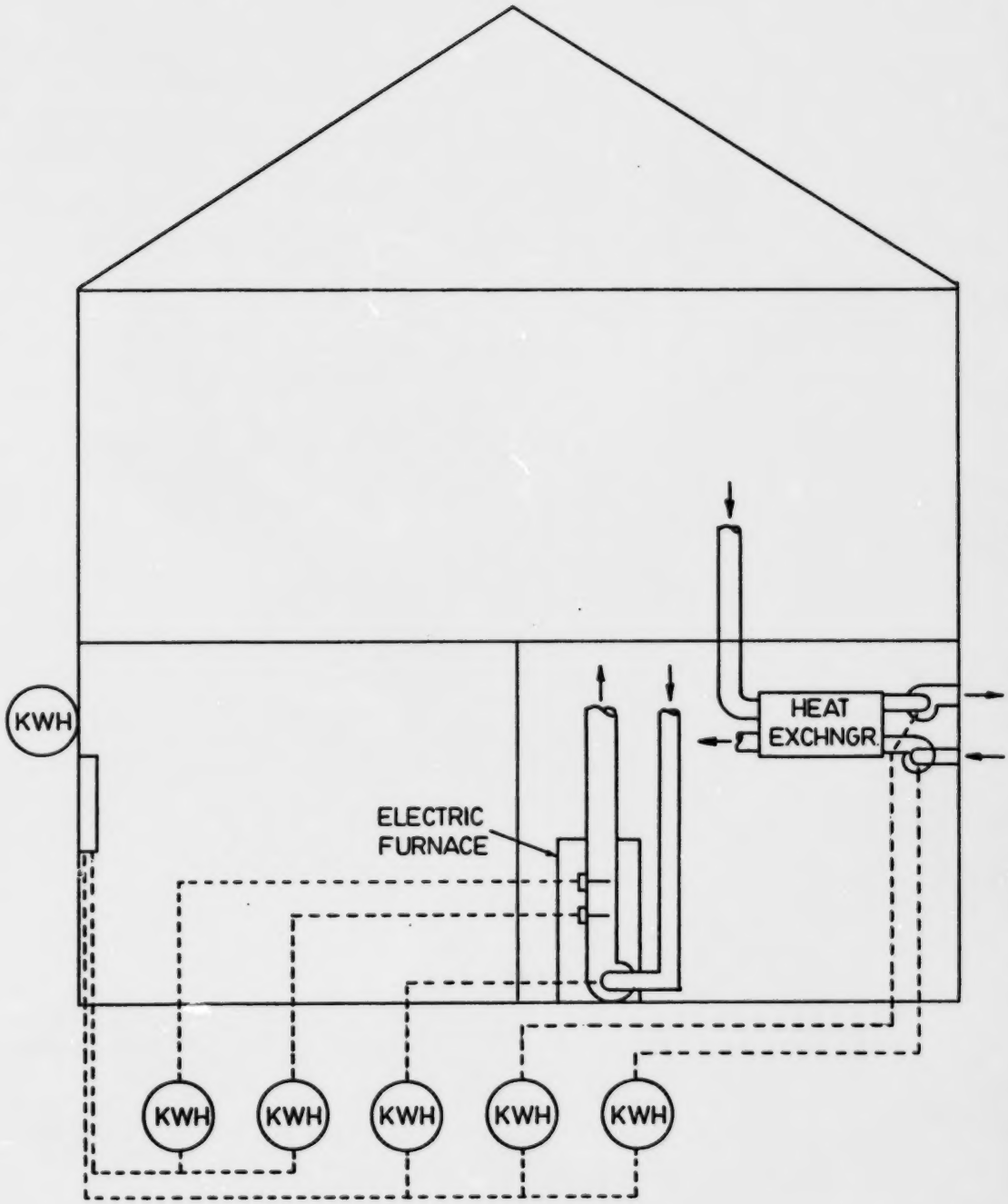


HEAT EXCHANGER
VENTILATION SCHEMATIC



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